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ABSTRACT

Hypertext and its more advanced form Hypermedia represent a powerful authoring tool with great potential for allowing statistics teachers to develop documents to assist students in an algorithmic fashion. An introduction to the use of Hypertext is presented, with an example of its use. Hypertext is an approach to information management in which data are stored in a network of nodes, or frames, connected by links. Nodes can contain text, graphics, audio, video, source code, or other forms of data. The designer of the document creates the nodes on a word processor, statistical package, or graphics program; he or she may go forward or backward through the links created. Hypertext documents are easy to use, although the number of levels of linkage should be kept to a minimum for students. Such documents are not as easy to create, requiring the creation of text files, linkage files created with Hypertext software, and graphics files. A sample Hypertext document is described for student learning about hypothesis tests for a single sample containing a parameter measuring the central tendency of the population. It is predicted that, in time, the text for an elementary statistics course will be a Hypertext document. Two sample flowcharts for use in the Hypertext document are provided. (SLD)

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USING HYPERTEXT TO DEVELOP AN ALGORITHMIC APPROACH TO TEACHING STATISTICS

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INTRODUCTION

Have you ever been frustrated in your effort to find the description of a certain statistical procedure in a text? After you have managed to find the procedure, have you then had difficulty trying to find, in the text, the assumptions needed to make the procedure valid for your problem? Have you ever wound up with the five fingers on one hand stuck in various pertinent sections of the text needed to solve your problem (some people rate texts by the number of fingers it takes to use them)?

O.K. Let's say you are one of those rare statisticians who have answered 'no' to the above questions. In the above questions replace 'text' with '(insert the name of your favorite statistical software package) Reference Manual'. Now tell us with a straight face that your answers are still 'no'.

We have all, at one time or another, faced the above problems and we are all 'statistical experts'. Imagine how students in (and out) of our statistics courses feel. In fact, isn't one of our goals, as teachers of statistics, to help in the evolution of our students from novice to expert? After all, an expert is more knowledgeable about his/her domain (statistics, in this instance) and, moreover, "an expert knows how to apply and use his knowledge more effectively than does a novice"[1].

To aid our students in selecting the most appropriate procedure for their problem, many of us have come up with flowcharts which, through a series of decisions (e.g., does the variable have a normal distribution), leads them to the procedure to use. Some of us have 'computerized' our flowcharts. Indeed, some of these computer programs allow students to enter their data into the analysis. Such programs are often labeled 'Statistical Expert Systems' or 'Statistical Consultants' (in truth, their name is some apocryphal acronym like 'SEX' or 'SCON').

The main goal of this paper is not to present another expert system for use by the statistical community but is, rather, to introduce a vehicle for creating both simple and sophisticated expert systems that a novice programmer can use to create such systems. It is user-friendly software that is available for PCs (for example, KnowledgePro[2] and Black Magic[3] for IBM PCs and Hypercard[4] on the Apple Macintosh) and workstations (for example, KMS[5]). The generic name for this type of software is Hypertext, or in its more advanced form, Hypermedia.

This paper contains a brief history and explanation of Hypertext and an example of a Hypertext document we created to help students decide which one-sample or two-sample inference technique is most appropriate for solving their problem.

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HYPERTEXT

The concept of Hypertext is attributed to Vanevar Bush, President Roosevelt's Science Advisor, in 1945 [7]. However, his name for it was Memex and, as he envisioned it, it would aid in bringing together data from a variety of sources in a logical fashion. He envisioned it as working like the human memory works, in an associative fashion. The actual term 'hypertext' was coined in the midsixties by Ted Nelson [8]. More details on the history and development of Hypertext may be found in references [9], and [10]. The broad use of Hypertext may be attributed to Apple's introduction of Hypercard in 1987. One particular example of the use of Hypertext is the coding of the New Oxford Dictionary and its Supplement (see [10] for more information). We look forward to the time when the Encyclopedia of Statistical Sciences is made available in Hypertext.

An encyclopedia is a good example to explain how a hypertext document works. Reading a book or a journal article is a one-dimensional exercise: you start at the beginning, and you go straight through to the end. On the other hand, reading an encyclopedia is not a one-dimensional process. We find ourselves flipping from one article to another. The articles are, usually, connected by certain key words or phrases. This exercise is sometimes much more than a five-finger job! We often wind up with fingers in different volumes.

Hypertext is increasingly being used to create computer-aided learning programs and to create electronic documents whose parts come from many sources. "More precisely, hypertext is an approach to information management in which data is stored in a network of nodes connected by links. Nodes can contain text, graphics, audio, video, as well as source code or other forms of data."[6] Hypertext does not create the nodes (also called frames). The designer of the document creates the nodes on a wordprocessor, or a statistical package, or a graphics program, etc. A node, or frame, is usually restricted to one computer screen of information. Once these frames have been imported to the Hypertext environment, Hypertext is used to link the frames together. The two basic ingredients of any Hypertext system are nodes and links. In our encyclopedia example, the articles would be the nodes and the nodes would be linked by key words and phrases. An important feature of a Hypertext document is that one may go backwards and forwards through the series of links created. Two users of a Hypertext document may arrive at the same node by entirely different paths. In Hypertext jargon, we do not 'read' a Hypertext document, we 'navigate' through it.

Hypertext documents may be viewed as interactive three-dimensional books. Any block of text, graphics, or video (the nodes or frames of the document) can be associated (linked) with any other block (node). Once two nodes are linked, they can provide an instant gateway to each other. Sometimes the nodes you link to will appear as a window on the current node (a pop-up window, sometimes called a note link) and other times the node linked to will replace the current node (a replacement link). On the other hand, a user may wish to go to an entirely new topic (links to new topics are called reference links). This is a reason why the nodes are recommended to be no larger than screen size. However, Hypertext does allow nodes larger than screen size. The user would scroll through these nodes as they would through a computerized user document for a software package. Hypertext is interactive because the choice of activating a certain link between two nodes is up to the user. This means that a Hypertext document is not necessarily the same each time it is read or navigated. Hypertext is three-dimensional

because it allows the user to work in more than one dimension by linking nodes to other nodes in different levels of the document. In effect, the links take the place of our fingers and the nodes correspond to procedures or articles. Further information about Hypertext navigation may be found in references [10] and [12].

We are mainly interested in using Hypertext to create documents for use by our students in elementary statistics courses. For this purpose the Hypertext system must have two features. First, any document we create must be easy for students to use. Second, it must be easy for us to create the documents.

Hypertext documents are easy to use. Our sample document runs on an IBM PC, or compatible, with an EGA or VGA card (documents may also be created for PCs with Hercules or CGA cards), about 400K of memory and a hard disk. To make full use of the document, a student must remember four commands (<F1>, <ESC>, <F10>, and <ALT><F10>). These commands activate a link, return from a link, go to the main menu, and exit the program, respectively. The student must also be able to use the four arrow keys. If the PC has a mouse, it can be used. In short, Hypertext documents are quite easy to navigate. The only major problem we found in navigating large documents was that a novice user could get lost in the document. For this reason, Hypertext documents for student use should keep the number of levels of linkage to a minimum.

It would be nice if Hypertext documents were as easy to create as they are to navigate. This is not the case. Each node must be in a file. There are three types of files we needed to create for our document: text files, linkage files, and graphics files. Text files are ASCII files created using an editor or word processor. Linkage files are files created with our Hypertext software. These files have links to other files. Graphics files are bit-mapped files. These files are created in several steps. The first step is to enable our Hypertext screen capture utility (a terminate and stay resident (TSR) program). The next step is to use our favorite statistical or graphical package to create a graphical image on the screen. This screen is then captured and placed in a graphics file by our screen capture utility. Once we have crated all the files we will need, we use Hypertext to link these files together in an appropriate fashion.

Hypertext documents may have other features. Most contain bookmarks. A bookmark is a pointer you may create when you leave the document. The next time you enter the document you will be where you left off on your last navigation. Some Hypertext contain a 'history' feature (see [11]). This feature informs you of the nodes you have visited and may even let you know how long you spent in a node. A feature that may be particularly useful to students is the annotation feature. If a Hypertext document possesses this feature, a student may customize the document to their own need by adding personal comments to their document (much as they might add notes in the margin of their text). Another feature most Hypertext documents possess is the ability to leave the document and run other software and then return to the document. This feature is particularly useful if the document concerns the use of a particular statistical software package.

A final feature, which is quite important to many teachers, is that good Hypertext software may be obtained at a reasonable price. The software we used to create the Hypertext version of this paper and our statistical flowchart example is shareware (if you use the software and wish to continue using it, you pay the author).

AN EXAMPLE

Hypertext documents, like textbooks, must be created with their potential audience in mind. For our example we assume that our audience will be students in an elementary statistics course (pre-calculus). The tool we have created would be introduced during the hypothesis testing portion of the course. Students have already learned about descriptive statistical techniques and they have also had a brief introduction to probability. They have used the normal distribution, the binomial distribution, and have been introduced to the central limit theorem. For example, suppose the course text is Introduction to the Practice of Statistics [13]. They have covered the first seven chapters of the text and are learning about hypothesis tests, for a single sample, concerning a parameter measuring central tendency of the population (population mean or median).

There are six tests that they are taught. One of these tests, the Wilcoxon signed rank test, is not covered in this text. To assist them in deciding which test is most appropriate for their problem, the instructor has created a flowchart. This flowchart is presented in Figure 1. A flowchart is a one dimensional document. The user starts at the top and follows the most appropriate path to the bottom. A flowchart has several good features. It only takes up one page, it is fairly easy to read, and a student can have it readily available when doing problems. Also, the student can annotate it. For example, under the box labeled "Sign Test For Median" the student might write "page 524 of the text". A flowchart has one big disadvantage: by its very nature, the amount of information it may contain is limited. For example: "When is a sample size large?", "How do we transform to normality?", "When is a variable discrete and when is it continuous?". We would like to have the details of how to do each test included on the chart, but ran out of space.

Our Hypertext document address these problems. Suppose the student is specifically interested in measures of central tendency for the single sample problem. They can look for this portion of the Table of Contents in our document and bring the appropriate flowchart up on their computer screen. This flowchart appears in the top portion of Figure 1. Note that each box in the flowchart has an icon in it. If the student is unsure of which box to select, they move the cursor to that box and press a button (for our document, <F1>). Depending on which box they are in, either a note window will be overlaid on the flowchart or the flowchart screen will be replaced with another screen. In the case of the note window, the student will read the information in the window, and then press another button (<ESC>) to return to the flowchart. In the case where they get the replacement screen, several options may be available. They might scroll up and down through the document provided on the screen (it might contain more than one screen of information), or they might read what is on the screen and then return to the flowchart. On the other hand, the replacement screen might have links to other replacement nodes and/or note windows. Once a series of links has been created, the student may scroll forward and backward through them as often as they desire.

As a concrete example suppose the flowchart in the top of Figure 1 is showing on the screen. If the student wanted more information about a Bernoulli variable, they could move the cursor to the box "X is Bernoulli" and press <F1>. A note window would be overlaid in the flowchart providing the definition of a Bernoulli variable. Returning (<ESC>) to the flowchart the student could navigate to the box "Normal Procedure for Proportion" and

press <F1>. The flowchart screen would be replaced by a detailed description of normal inferential procedures, supplemented by examples. Should the student be interested in a variable which was neither normal nor Bernoulli, they would move the cursor to the box "X has Some Other Distribution" and press <F1>. The flowchart in the top of Figure 1 would be replaced by the lower flowchart. Then the student could navigate this flowchart on the screen to obtain the desired information.

Of course, the deeper the system of links created in the document, the more difficult it is to create such a document and, more importantly, the easier it will be for the student to get lost when using it. We believe that documents created for student use should keep the level of linkage to a minimum. To accomplish this, many of our end nodes simply refer the student to the appropriate section of the text. Topics not covered in the text, or topics covered inadequately by the text, would usually require a higher level of linkage.

Although Hypertext is easy to use, it is not easy to define or explain in a linear document. Hypertext, by its very nature, is nonlinear reading (or writing, if you are creating the document). We encourage the reader to experiment on their PC with our document, or some other Hypertext document, to gain a full appreciation of its power.

CONCLUSION

Hypertext, or Hypermedia, is a powerful new authoring tool which has great potential for allowing statistics teachers to develop documents to assist students to learn statistics in an algorithmic fashion. This paper presented an introduction to the use of Hypertext and a simple example of its use. We predict that the use of Hypertext will grow at the rate that PCs and workstations become available for student use. Simple Hypertext documents fit quite easily onto a floppy disk. The proper use of such documents can free the instructor from spending so much class time on presenting recipes to the student. The free time created may be spent in the presentation of more real examples of statistical analysis. More class time may also be spent developing the concepts underlying statistical analysis. Hypertext documents may serve to reinforce these concepts outside of the classroom.

We predict that there will come a time when the 'text' for the course will be a Hypermedia document. Imagine Moore and McCabe's book and text linked together in one Hypermedia document. Such a document is now possible. More advanced versions of Hypertext software have videodisc and digitized sound support. Moreover, the newer systems may also access statistical software packages and, thus, allow the presentation of the new dynamic graphical statistical techniques.

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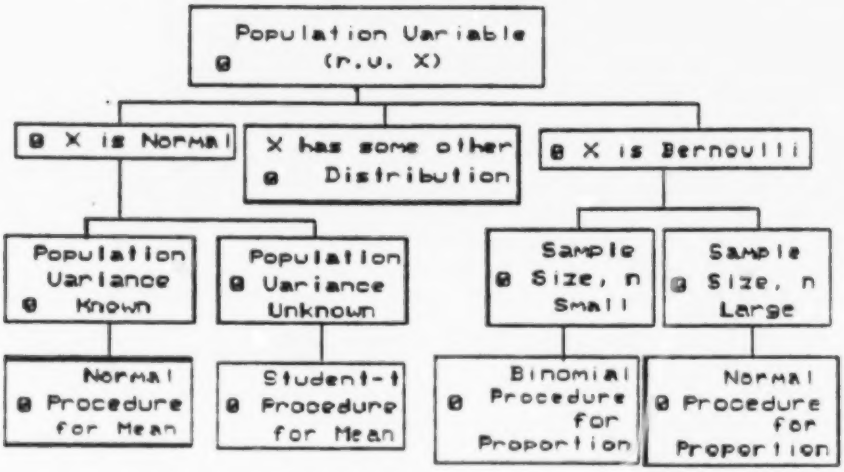
Central Tendency



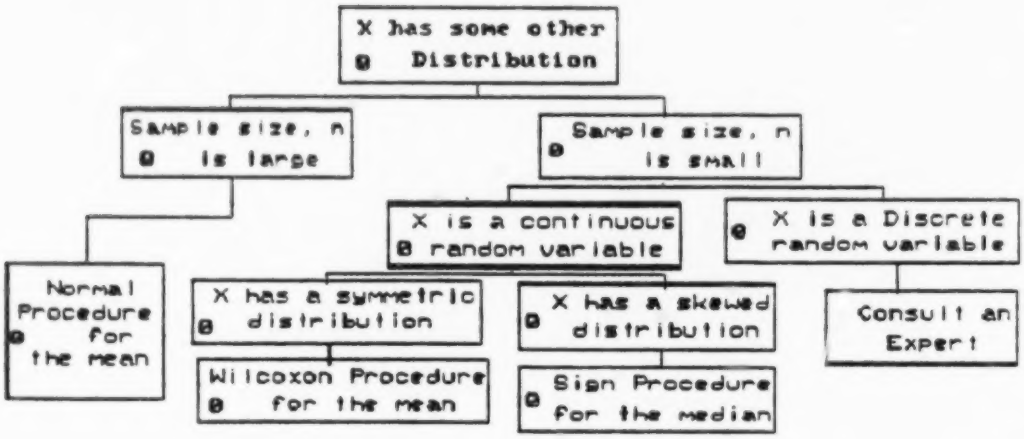


Figure 1